CLAIMS

What is claimed is:

1   1. A charge pump for receiving control signals, the charge pump sourcing and

2   sinking current in response to the control signals, the charge pump comprising:

3   a main current source;

4   a secondary current source;

5   a main current sink;

6   a secondary current sink;

7   three current paths provided between the current sources and the current sinks,

8   wherein a first current path and an output node is provided between the main current source

9   and the main current sink, a second current path is provided between the main current source

10   and the secondary current sink, and a third current path is provided between the secondary

11   current source and the main current sink.

1   2. The charge pump of claim 1 wherein each of the three parallel current paths

2   includes at least one switch.

1   3. The charge pump of claim 2 wherein three current paths are parallel current paths,

2   and wherein each of the three current paths includes an upper switch connected in series with

3   a lower switch, wherein the common node of the switches of the first current path defines the

4   output node.

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1   4. The charge pump of claim 3 wherein the common nodes of the switches of the

2   second and third current paths define two central nodes, and further comprising first and

3   second buffers operative to maintain the node voltages of the central nodes of the second and

4   third current paths at the same voltage as the output node, each buffer coupled between two

5   of the current paths.

1   5. The charge pump of claim 4 wherein the first and second buffers each have an

2   input node coupled to the output node, and wherein the first and second buffers have output

3   nodes coupled to the central nodes of the second and third current paths, respectively.

1   6. The charge pump of claim 4 wherein the first and second buffers each include an

2   amplifier connected as a unity gain buffer.

1   7. The charge pump of claim 3 wherein each upper switch includes a P-channel

2   transistor, and each lower switch includes an N-channel transistor.

1   8. The charge pump of claim 2 further comprising:

2   a replica current source;

3   a replica current sink;

4   a replica current path and a replica node provided between the replica current source

5   and the replica current sink, wherein the replica current path is parallel to the other current

6   paths and includes at least one switch.

1   9. The charge pump of claim 8 wherein the replica current path includes an upper

2   switch connected in series with a lower switch, the common nodes of the switches defining

3   the replica node.

1   10. The charge pump of claim 9 further comprising a capacitor, wherein the replica

2   node is coupled to a first node of the capacitor, and a second node of the capacitor is coupled

3   to a low supply voltage.

1   11. The charge pump of claim 9 further comprising a replica feedback element

2   operative to balance the currents in the current sources and current sinks.

1   12. The charge pump of claim 11 wherein the replica feedback element includes an

2   amplifier, the amplifier having a first input coupled to the replica node and a second input

3   coupled to the output node, the amplifier having a first output coupled to current amplitude

4   control nodes of all the current sources, and the amplifier having a second output coupled to

5   the current amplitude control nodes of all the current sinks.

1   13. The charge pump of claim 11, wherein a central node is provided on the each of

2   the second and third current paths, and wherein the two buffers and the three parallel current

3   paths, the replica feedback element, and the replica path adjust the current sources and

4   current sinks in any combination to maintain the node voltage of the central nodes and the

5   voltage of the output node at the same potential and to balance current amplitude of the

6   current sources and current sinks so as to minimize DC offsets at the output.

1   14. A charge pump for receiving control signals, the charge pump sourcing and

2   sinking current in response to the control signals, the charge pump comprising:

3   a current source;

4   a current sink;

5   at least three current paths provided between the current source and the current sink,

6   wherein each of the current paths includes at least one switch, wherein an output node is

7   defined on one of the current paths and central nodes are defined on the other current paths;

8   and

9   a plurality of buffers operative to maintain the node voltages of the central nodes at

10   the same voltage as the output node, wherein each buffer is coupled between two of the three

11   current paths.

1   15. The charge pump of claim 14 wherein the plurality of buffers each have an input

2   node coupled to the output node, and wherein one buffer has an output node coupled to a first

3   one of the central nodes, and a different buffer has an output mode coupled to a second one

4   of the central nodes.

1   16. The charge pump of claim 15 further comprising a secondary current source and

2   a secondary current sink, wherein a first current path and the output node is provided

3   between the main current source and the main current sink, a second current path is provided

4   between the main current source and the secondary current sink, and a third current path is

5   provided between the secondary current source and the main current sink.

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1   17. The charge pump of claim 16 wherein the at least one switch for each of the

2   current paths includes an upper switch connected in series with a lower switch, wherein the

3   common node of the switches of one of the current paths defines an output node, and wherein

4   the common nodes of the switches of the other current paths define central nodes.

1   18. The charge pump of claim 17 further comprising:

2   a replica current source;

3   a replica current sink;

4   a replica current path provided between the replica current source and the replica

5   current sink, wherein the replica current path is parallel to the other current paths and

6   includes an upper switch connected in series with a lower switch, the common nodes of the

7   switches defining a replica node;

8   a capacitor, wherein the replica node is coupled to a first node of the capacitor, and a

9   second node of the capacitor is coupled to a ground; and

10   a replica feedback element operative to balance the currents in the current sources and

11   current sinks, the replica feedback element including an amplifier having a first input coupled

12   to the replica node, a second input coupled to the output node, a first output coupled to

13   current amplitude control nodes of the current sources, and a second output coupled to the

14   current amplitude control nodes of all the current sinks.

1   19. A method for sourcing and sinking current in a charge pump in response to input

2   control signals, the method comprising:

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3   (a) providing a current source and a current sink and three current paths between the

4   current source and current sink, wherein an output node is defined between the current source

5   and current sink on the first current path and a central node is defined on each of the second

6   and third current paths; and

7   (b) adjusting output current at the output node based on the input control signals; and

8   (c) maintaining the voltages at the central nodes of the second and third current paths

9   at approximately the same voltage as the output node.

1   20. The method of claim 19 wherein the current source and current sink are both

2   turned on during sourcing output current and during sinking output current at the output node

3   of the charge pump.

1   21. The method of claim 19 further comprising providing a secondary current source

2   and a secondary current sink, wherein the three current paths are parallel current paths, and

3   wherein one current path is provided between the main current source and the main current

4   sink, the second current path is provided between the main current source and the secondary

5   current sink, and the third current path is provided between the secondary current source and

6   the main current sink.

1   22. The method of claim 21 wherein each of the three parallel current paths includes

2   an upper switch connected in series with a lower switch, wherein the common node of the

3   first current path defines an output node, and wherein the common nodes of the second and

4   third current paths define two central nodes.

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23. The method of claim 19 wherein the maintaining is performed using first and second buffers, wherein the first and second buffers each have an input node coupled to the output node, and wherein the first and second buffers have output nodes coupled to the central nodes of the second and third current paths, respectively.

24. The method of claim 19 further comprising balancing the currents of the current sources and the current sinks.

25. The method of claim 24 wherein the balancing of the currents is performed using a replica current path having a replica node provided between a replica current source and a replica current sink, and an amplifier.

26. The method of claim 25 wherein the amplifier has a first input coupled to the replica node and a second input coupled to the output node, the amplifier having a first output node coupled to current amplitude control nodes of all the current sources, and the amplifier having a second output node coupled to the current amplitude control nodes of all current sinks.

27. The method of claim 19 wherein the input control signals include UP, inverse UP, DN, and inverse DN control signals developed by a phase-frequency detector.

28. A method for sourcing and sinking current in a charge pump in response to input control signals, the method comprising:

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3   (a) providing a main current source, a secondary current source, a main current sink,

4   and a secondary current sink;

5   (b) providing three current paths between the current sources and current sinks,

6   wherein a first current path and an output node is provided between the main current source

7   and the main current sink, a second current path is provided between the main current source

8   and the secondary current sink, and a third current path is provided between the secondary

9   current source and the main current sink; and

10   (c) adjusting output current at the output node based on input control signals.

1   29. The method of claim 28 wherein an output node is defined between the main

2   current source and main current sink on the first current path and a central node is defined on

3   each of the second and third current paths, and wherein the adjusting output current includes

4   sourcing and/or sinking current at the output node.

1   30. The method of claim 29 further comprising maintaining the voltages at the

2   central nodes of the second and third current paths at approximately the same voltage as the

3   output node.

1   31. The method of claim 30 wherein the maintaining is performed using first and

2   second buffers, wherein the first and second buffers each have an input node coupled to the

3   output node, and wherein the first and second buffers have output nodes coupled to the

4   central nodes of the second and third current paths, respectively.

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1   32. The method of claim 28, wherein the three current paths are parallel current

2   paths, and wherein each of the three current paths includes an upper switch connected in

3   series with a lower switch, wherein the common node of the switches of the first current path

4   defines the output node, and wherein the common nodes on the second and third current

5   paths define the central nodes.

1   33. The charge pump of claim 28 further comprising:

2   providing a replica current source and a replica current sink; and

3   providing a replica current path and a replica node on the replica current path between

4   the replica current source and the replica current sink, wherein the replica current path is

5   parallel to the other current paths.